

Outline

- Background
- Channels and COM Settings for Analysis
- TP1a VEC Spec
- ERL sensitivity to test fixture
- Summary

TP1a VEC and H2M Short Channel Issue

- There were a lot of previous contributions focusing on TP1a VEC spec
 - sun 3ck 01b 0119, sun 3ck 01 0319, sun 3ck 01 0519,
li 3ck 01 0319, li 3ck 02a 0519, wu 3ck 01a 0919
- The followings proposed the ideas of combining VEC & VEO specs
 - ghiasi 3ck 02a 0919, sun 3ck 01b 0919,
wu 3ck adhoc 01 101619, sun 3ck adhoc 02 103019
- Host-2-module short channel issue were discussed in the following contributions
 - li 3ck 02a 0519, dudek 3ck 01 0719, sun 3ck adhoc 01 081419,
akinwale 3ck adhoc 01a 08282019, wu 3ck 01a 0919,
dudek 3ck 01 0919, sun 3ck 01b 0919, wu 3ck adhoc 02 101619
- C2M ERL spec was discussed in the following contributions
 - mellitz 3ck 02 0319, mellitz 3ck adhoc 01a 032719,
mellitz 3ck adhoc 01a 042419, mellitz 3ck 02a 0519

Channel and Analysis

- Channel and reference receiver
 - Whole-link & TP1a analysis for total nineteen IEEE C2M host-to-module channels
 - Sweep host package trace length, z_p1(TX)
 - z_p1(TX) = [5:0.5:10 11:1:20 22:2:36]
 - total 19 * 29 = 551 CH+PKG test cases
 - RX with sweeping tap number
 - DFE with 4 taps
- COM parameter settings [details in appendix]
 - COM 2.75
 - Whole link: TX PKG + H2M Channels + RX PKG
 - On-die
 - Host [healey_3ck_adhoc_01_061219]
 - Module: Table 1
 - PKG
 - Host [baseline]
 - Module: Table 1
 - g_DC = [-14:1:0] dB
 - g_DC_HP = [-3:1:0] dB
 - TP1a: TX PKG + H2M Channels
 - Set 'zero' to related RX PKG & on-die settings

Table 1

Spec	[Host, Module]	Unit
C_d	[1.2e-4 0.85e-4]	nF
L_s	[0.12 0.12]	nH
C_b	[0.3e-4 0.3e-4]	nF
R_d	[50 50]	Ohm
C_p	[0.87 0.65]	nF
z_p(RX)	[5 0]	Ohm

TP1a VEC and VEO Specs

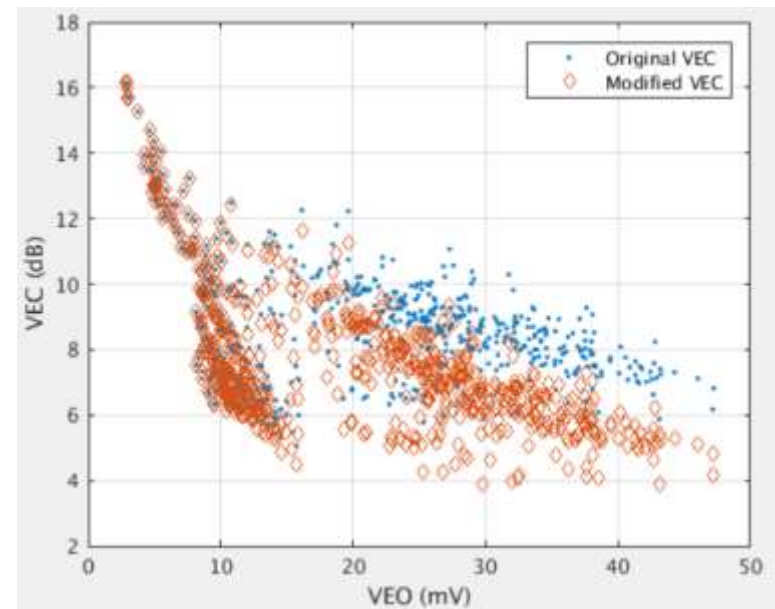
- In wu 3ck adhoc 01 101619, we explored VEC and VEO combined spec by exploring 19 channels with 29 host PKG trace lengths
 - Analyzed by considering false ratios by 3dB COM
- In sun 3ck adhoc 02 103019, 2.6mV receiver noise had been added for whole-link COM simulation
 - Proposed EVEC based on simulation results
- We explored EVEC by nineteen C2M channels
 - Add 2.0mV receiver noise with Effective COM (ECOM) ≥ 1.5 dB as criterion
 - Refer to wu 3ck 01a 0519 for receiver noise modeling
 - ECOM is the whole-link COM by adding 2.0mV RX noise
 - EVEC vs. ECOM gets better correlation comparing to VEC vs. ECOM
 - Refer to sun 3ck adhoc 02 103019 or wu 3ck adhoc 01 101619 for EVEC methodology
 - Proposed the following EVEC parameters

$$\text{EVEC}(i) = \begin{cases} \text{VEC}(i), & \text{if } \text{VEO}(i) < 10\text{mV} \\ \text{VEC}(i) - 0.3333 \times (\text{VEO}(i) - 10)\text{dB}, & \text{if } 10\text{mV} \leq \text{VEO}(i) < 25\text{mV} \\ \text{VEC}(i) - 5\text{dB} & \text{otherwise} \end{cases}$$

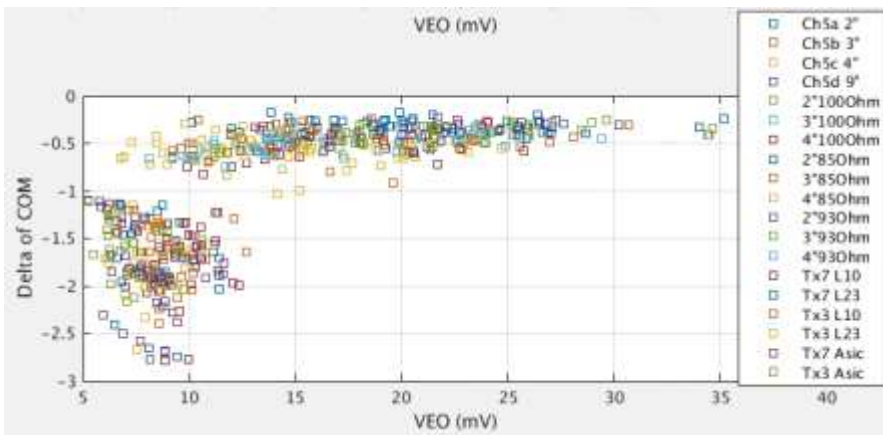
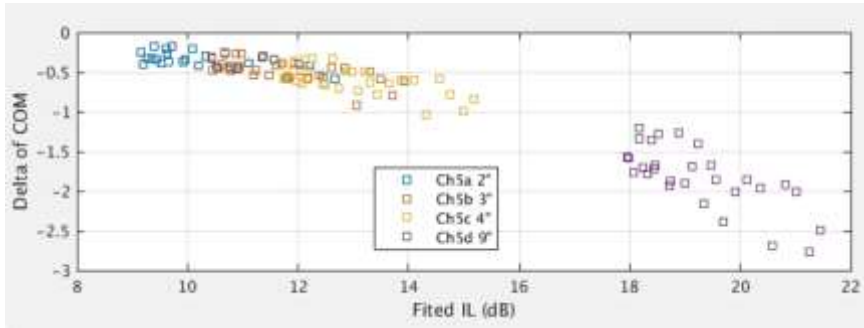
EVEC Threshold

- Ideas
 - If VEO is larger than some specific threshold (VEO_0), VEC threshold could be relaxed (larger)
- Derivative of **EVEC**, Effective VEC

- $$EVEC(i) = \begin{cases} VEC(i), & \text{if } VEO(i) < VEO_0 \\ VEC(i) - Slope_m \times (VEO(i) - VEO_0), & \text{if } VEO_0 \leq VEO(i) < VEO_1 \\ VEC(i) - (VEC_1 - VEC_0), & \text{otherwise} \end{cases}$$
- Where $Slope_m = (VEC_1 - VEC_0) / (VEO_1 - VEO_0)$



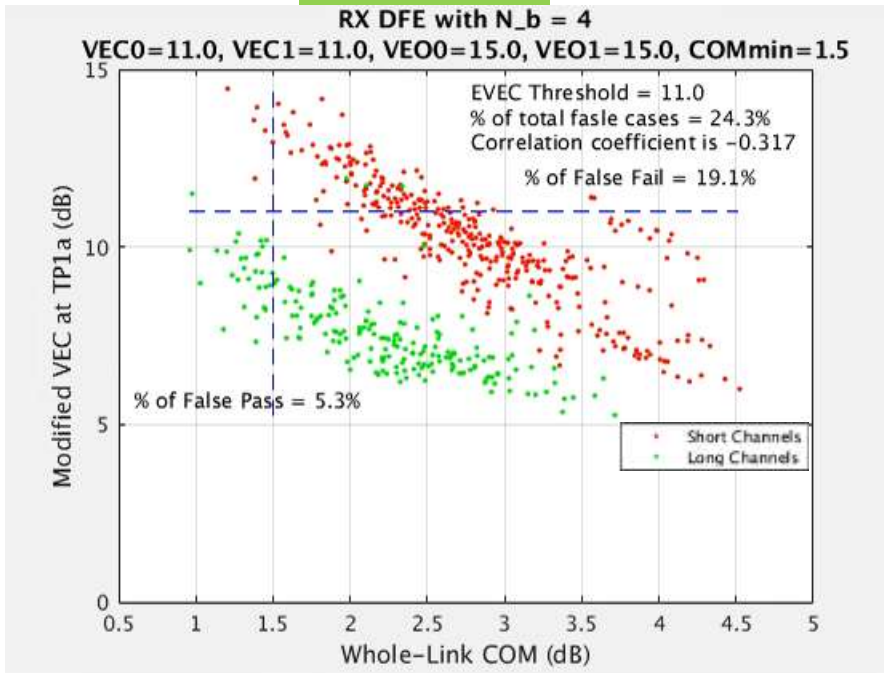
Impact of 2mV Receiver Noise



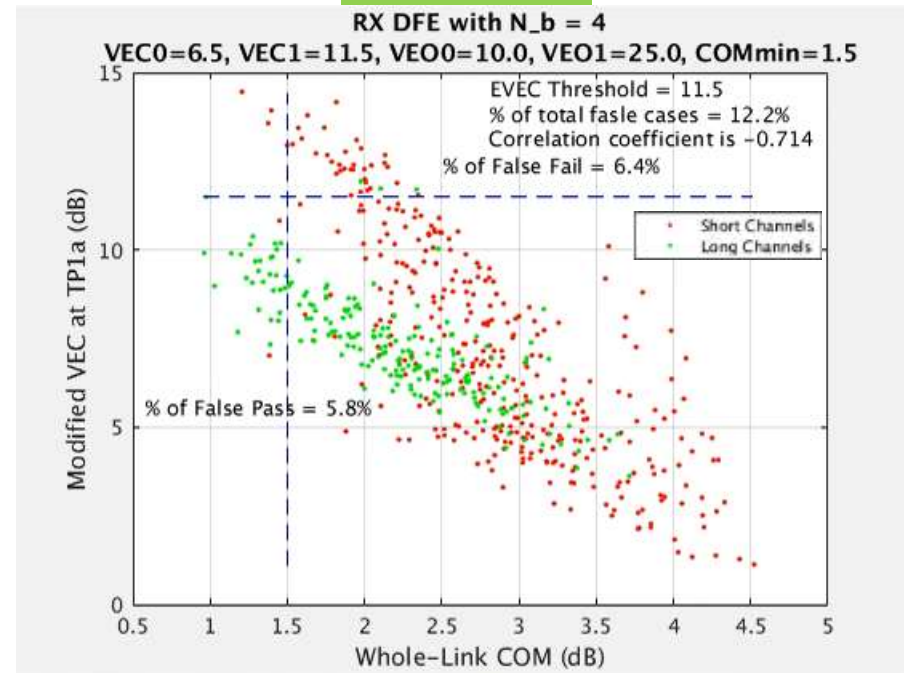
- ❑ 3dB minimum COM limit topic had been explored in healey 3ck 01 0319
 - 3dB for RX noise, sampling clock jitter, approximation errors, ...
- ❑ A lot of C2M short channels fail 3dB COM for several TX package lengths
 - wu 3ck 01a 0919
- ❑ Add 2mV RX noise in whole-link analysis
 - Set COM results as ECOM
 - $\Delta \text{ of COM} = \text{COM}(2\text{mV}) - \text{COM}(0\text{mV})$
- ❑ COM loss due to RX noise
 - 0.5 ~ 1.0 dB for short channels, 1.5 ~ 2.5 dB for long channels
 - COM loss is also correlated to VEO
- ❑ $\text{COM}_{\min} = 3.0 \text{ dB}$ for short channel may be too pessimistic
 - $\text{ECOM}_{\min} = 1.5 \text{ dB}$ shall be OK
 - Apply EVEC at TP1a & make sure it's correlated to ECOM
 - C2M short channel issue is NOT severe as we previously thought

EVEC Improves Correlation to COM

No EVEC



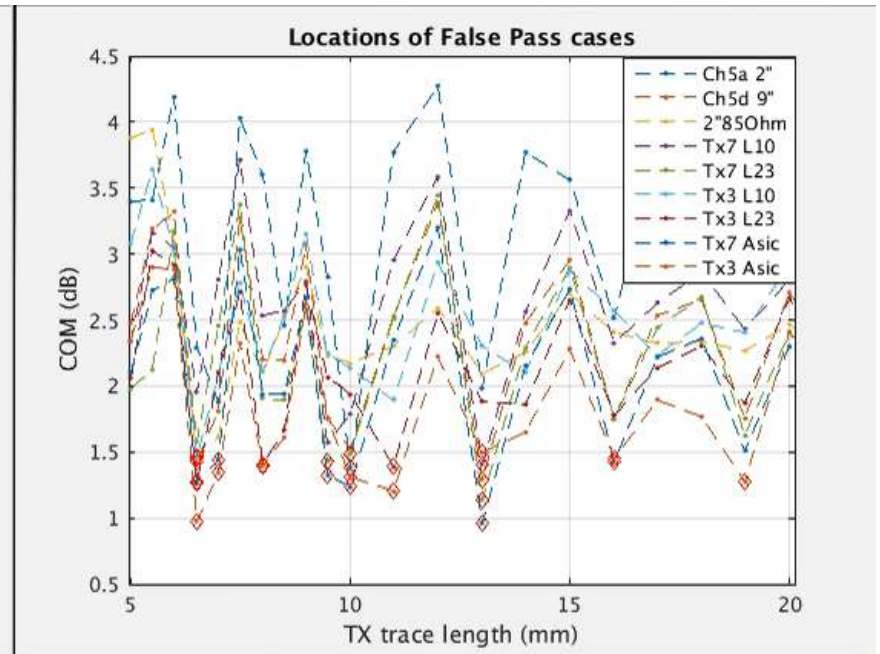
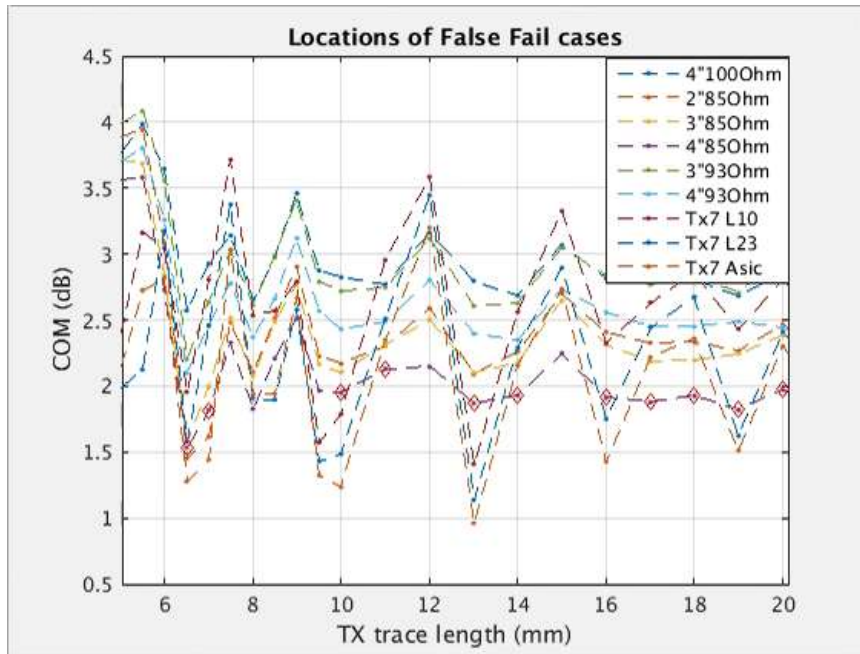
Proposal



- ❑ Short and long channels are grouped obviously
 - but correlation coefficient (CC) is low (-0.317)
- ❑ Difficult to set VEC_{max}
 - VEC_{max} = 11 dB, % of False case = 24.3%
 - False Fail: majorly 'short channels'

- ❑ Correlation has improved a lot
 - -0.317 → -0.714
- ❑ False %: improve from 24.3% to 12.2%
 - Most on False Fail
 - Little on False Pass

False Pass and False Fail Cases



$$EVEC(i) = \begin{cases} VEC(i), & \text{if } VEO(i) < 10mV \\ VEC(i) - 0.3333 \times (VEO(i) - 10)dB, & \text{if } 10mV \leq VEO(i) < 25mV \\ VEC(i) - 5dB & \text{otherwise} \end{cases}$$

C2M ERL Spec

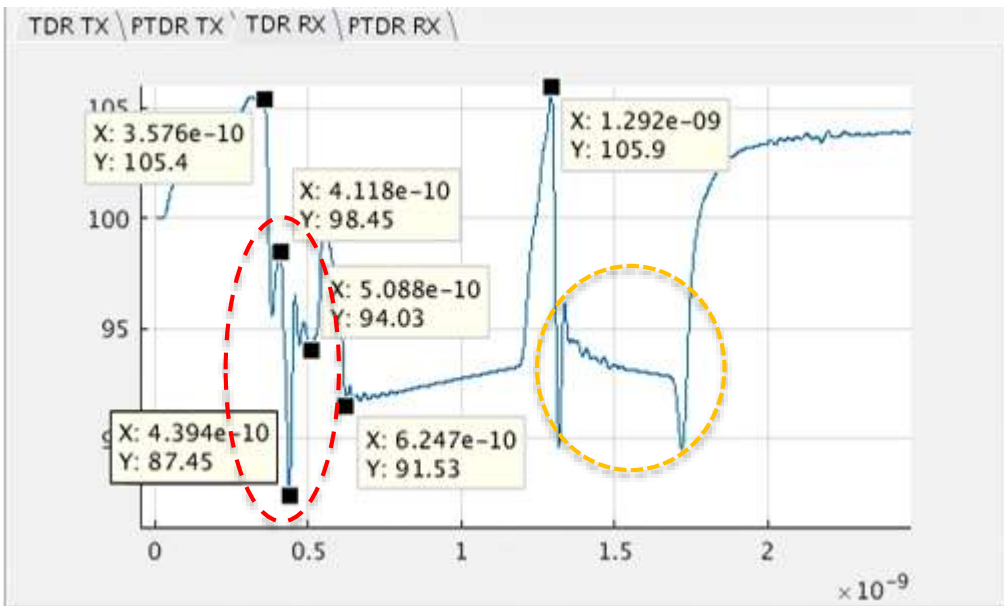
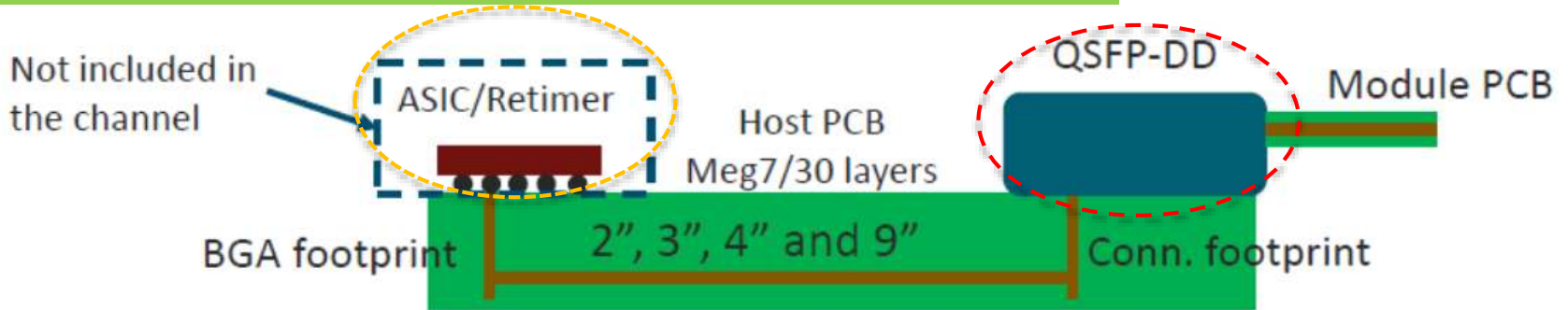
136.9.3.4 Transmitter effective return loss (ERL)

ERL of the transmitter at TP2 is computed using the procedure in 93A.5 with the values in Table 136–13. Parameters that do not appear in Table 136–13 take values from Table 136–18. The value of T_{fx} is twice the delay associated with the TP2 test fixture being used. N_{bx} is set to the value of N_b in Table 136–18.

- Idea: leverage 50G-CR ERL & change TP2 to TP1a?
 - TX ERL is sensitive to T_{fx} and we shall define clearly the meaning of 'twice the delay associated with the TP1a test fixture being used'
- Is it straight forward?
- Suggestion
 - To have more specific definitions of T_{fx}

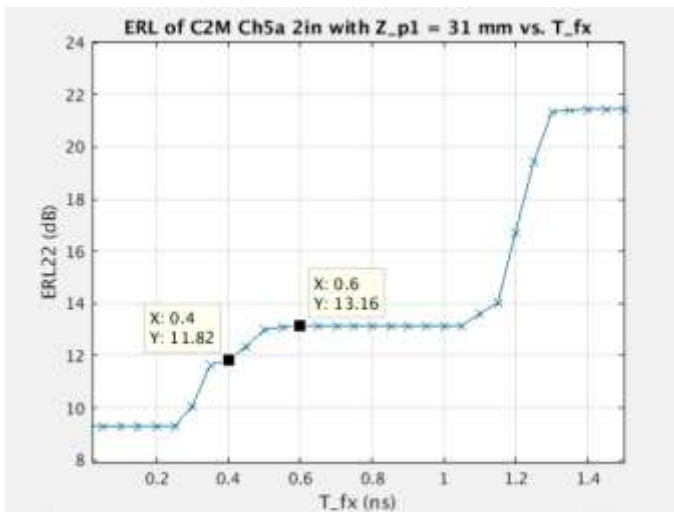
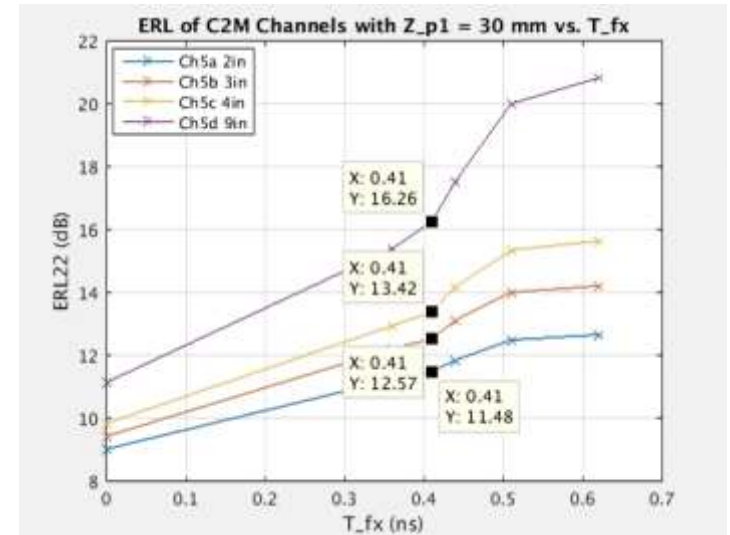
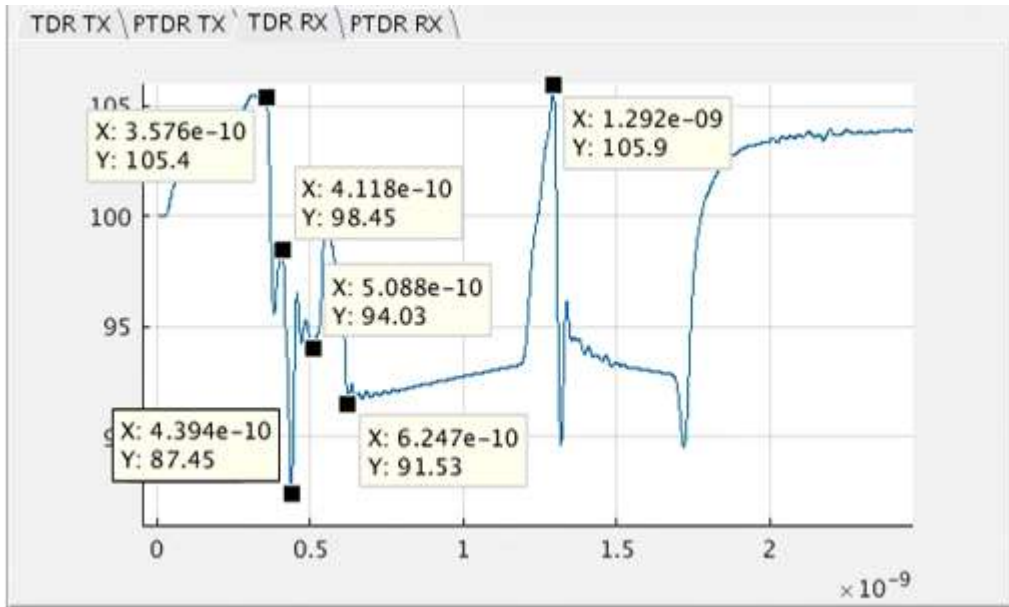
What's T_{fx} ?

Lim's C2M short channels, lim_3ck_adhoc_01_073119



- Where is the TP1a point? $T_{fx} = ?$
 - $3.58e-10$, $4.12e-10$, ... or $6.25e-10$
- Shall include QSFP-DD?
 - Take $4.1e-10$
- ERL22 is sensitive to T_{fx}
 - Shall we have more specific definitions for T_{fx} ?

ERL Sensitivity to T_{fx}



- ERL22 is sensitive to T_{fx} = ?
 - Yes
 - Be careful to exclude 'TP1a test fixture', while include QSFP-DD or OSFP
- ERL22 of Jane Lim's C2M short channels (by $T_{fx} = 0.41$ ns)

Channel	2in	3in	4in	9in
ERL22 (dB)	11.48	12.57	13.42	16.26

Summary

- By DFE reference receiver, 4-tap DFE has good correlation for TP1a EVEC vs. whole-link COM plus RX noise
 - With total false ratio = 12.2% with -0.71 correlation
 - Propose the following EVEC parameters

$$\begin{aligned} & \text{EVEC}(i) \\ &= \begin{cases} \text{VEC}(i), & \text{if } \text{VEO}(i) < 10\text{mV} \\ \text{VEC}(i) - 0.3333 \times (\text{VEO}(i) - 10)\text{dB}, & \text{if } 10\text{mV} \leq \text{VEO}(i) < 25\text{mV} \\ \text{VEC}(i) - 5\text{dB} & \text{otherwise} \end{cases} \end{aligned}$$

- C2M TP1a ERL is sensitive to T_{fx}
 - Suggest to have more specific definition of TP1a test fixture and T_{fx} accordingly



everyday genius



C2M Host-to-Module Channels for Analysis

- Short Channel
- Long Channel

Contribution	Zip files	Channel	SxP Files
lim_3ck_01a_0319	lim_3ck_01_0319_c2m.zip	Tx7_L10 ●	112G_16dB_(QSFPDD+module card)_TX7_L10
		Tx7_L23 ●	112G_16dB_(QSFPDD+module card)_TX7_L23
		Tx3_L10 ●	112G_16dB_(QSFPDD+module card)_TX3_L10
		Tx3_L23 ●	112G_16dB_(QSFPDD+module card)_TX3_L23
		Tx7_Asic ●	112G_16dB_(QSFPDD+module card)_TX7_Asic
		Tx3_Asic ●	112G_16dB_(QSFPDD+module card)_TX3_Asic
lim_3ck_adhoc_01_073119	lim_3ck_adhoc_02_073119.zip	Ch5a_2" ●	Channel5a_Smaller_Pad_2inch_trace
		Ch5b_3" ●	Channel5b_Smaller_Pad_3inch_trace
		Ch5c_4" ●	Channel5c_Smaller_Pad_4inch_trace
		Ch5d_9" ●	Channel5d_Smaller_Pad_9inch_trace
akinwale_3ck_C2M_channels_TP0a_100ohms_08222019.zip	akinwale_3ck_C2M_channels_TP0a_100ohms_08222019.zip	2"100Ohm ●	C2M_2p0in_100Ohm_thru1.s4p
		3"100Ohm ●	C2M_3p0in_100Ohm_thru1.s4p
		4"100Ohm ●	C2M_4p0in_100Ohm_thru1.s4p
		2"85Ohm ●	C2M_2p0in_85Ohm_thru1.s4p
	akinwale_3ck_C2M_channels_TP0a_85ohms_08222019.zip	3"85Ohm ●	C2M_3p0in_85Ohm_thru1.s4p
		4"85Ohm ●	C2M_4p0in_85Ohm_thru1.s4p
		2"93Ohm ●	C2M_2p0in_93Ohm_thru1.s4p
		3"93Ohm ●	C2M_3p0in_93Ohm_thru1.s4p
akinwale_3ck_adhoc_01a_08282019	akinwale_3ck_C2M_channels_TP0a_93Ohms_08222019.zip	4"93Ohm ●	C2M_4p0in_93Ohm_thru1.s4p

COM Settings – Whole Link

Table 93A-1 parameters				I/O control				Table 93A3 parameters			
Parameter	Setting	Units	Information	DIAGNOSTICS	1	logical	Parameter	Setting	Units		
f_b	53.125	GBd		DISPLAY_WINDOW	0	logical	package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]			
f_min	0.05	GHz		CSV_REPORT	1	logical	package_tl_tau	6.141E-03	ns/mm		
Delta_f	0.01	GHz		RESULT_DIR	.\results\100GEL_KR_{date}\		package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm		
C_d	[1.2e-4 0.85e-4]	nF	[TX RX]	SAVE_FIGURES	1	logical	Table 9242 parameters 5.2dB at 26.56GHz				
L_s	[0.12, 0.12]	nH	[TX RX]	Port Order	[2 1 4 3]		Parameter	Setting			
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	RUNTAG	KR_eval_		board_tl_gamma0_a1_a2	[0 0.000599 0.0001022]	1.286 dB/in or 0.0506 dB/mm at 100 ohms		
z_p select	[1 2]		[test cases to run]	COM_CONTRIBUTION	0	logical	board_tl_tau	6.200E-03	ns/mm		
z_p (TX)	[12 16; 1.8 1.8]	mm	[test cases]	Operational			board_Z_c	90	Ohm		
z_p (NEXT)	[2 5; 0 0]	mm	[test cases]	COM Pass threshold	3	dB	z_bp (TX)	102.7	mm		
z_p (FEXT)	[12 16; 1.8 1.8]	mm	[test cases]	ERL Pass threshold	10	dB	z_bp (NEXT)	102.7	mm		
z_p (RX)	[2 5; 0 0]	mm	[test cases]	DER_0	1.00E-05		z_bp (FEXT)	102.7	mm		
C_p	[0.87e-4 0.65e-4]	nF	[TX RX]	T_r	6.16E-03	ns	z_bp (RX)	102.7	mm		
R_0	50	Ohm		FORCE_TR	1	logical					
R_d	[50 50]	Ohm	[TX RX]	Include PCB	0	logical					
A_v	0.39	V	vp/vf=.694	TDR and ERL options							
A_fe	0.39	V	vp/vf=.694	TDR	1	logical	Floating Tap Control				
A_ne	0.578	V		ERL	1	logical	N_bg	0	0 1 2 or 3 groups		
L	4			ERL_ONLY	0	logical	N_bf	0	taps per group		
M	32			TR_TDR	0.01	ns	N_f	40	UI span for floating taps		
filter and Eq				N	3000		bmaxg	0.2	max DFE value for floating taps		
f_r	0.75	*fb		beta_x	2.53E+09						
c(0)	0.54		min	rho_x	0.25						
c(-1)	[-0.26:0.02:0]		[min:step:max]	fixture delay time	0	s					
c(-2)	[0:0.02:0.10]		[min:step:max]	TDR_W_TXPKG	1						
c(-3)	[-0.04:0.02:0]		[min:step:max]	N_bx	24	UI	yellow indicates WIP				
c(1)	[-0.2:0.05:0]		[min:step:max]	Receiver testing							
N_b	4	UI		RX_CALIBRATION	0	logical					
b_max(1)	0.5			Sigma BBN step	5.00E-03	V					
b_max(2..N_b)	0.2			Noise, jitter							
g_DC	[-14:1:0]	dB	[min:step:max]	sigma_RJ	0.01	UI					
f_z	21.25	GHz		A_DD	0.02	UI					
f_p1	21.25	GHz		eta_0	8.20E-09	V^2/GHz					
f_p2	53.125	GHz		SNR_TX	33	dB					
g_DC_HP	[-3:1:0]		[min:step:max]	R_LM	0.95						
f_HP_PZ	0.6640625	GHz									

PS: Ran for test case 2 only

COM Settings – TP1a

Table 93A-1 parameters				I/O control			Table 93A3 parameters			
Parameter	Setting	Units	Information	DIAGNOSTICS	1	logical	Parameter	Setting	Units	
f_b	53.125	GBd		DISPLAY_WINDOW	0	logical	package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]		
f_min	0.05	GHz		CSV_REPORT	1	logical	package_tl_tau	6.141E-03	ns/mm	
Delta_f	0.01	GHz		RESULT_DIR	.\results\100GEL_KR_{date}\		package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm	
C_d	[1.2e-4 0]	nF	[TX RX]	SAVE_FIGURES	1	logical	Table 9242 parameters 5.2dB at 26.56GHz			
L_s	[0.12, 0]	nH	[TX RX]	Port Order	[2 1 4 3]		Parameter	Setting		
C_b	[0.3e-4 0]	nF	[TX RX]	RUNTAG	KR_eval_		board_tl_gamma0_a1_a2	[0 0.000599 0.0001022]	1.286 dB/in or 0.0506 dB/mm at 100 ohms	
z_p select	[1 2]		[test cases to run]	COM_CONTRIBUTION	0	logical	board_tl_tau	6.200E-03	ns/mm	
z_p (TX)	[12 16; 1.8 1.8]	mm	[test cases]	Operational			board_Z_c	90	Ohm	
z_p (NEXT)	[0 0; 0 0]	mm	[test cases]	COM Pass threshold	3	dB	z_bp (TX)	102.7	mm	
z_p (FEXT)	[12 16; 1.8 1.8]	mm	[test cases]	ERL Pass threshold	10	dB	z_bp (NEXT)	102.7	mm	
z_p (RX)	[0 0; 0 0]	mm	[test cases]	DER_0	1.00E-05		z_bp (FEXT)	102.7	mm	
C_p	[0.87e-4 0]	nF	[TX RX]	T_r	6.16E-03	ns	z_bp (RX)	102.7	mm	
R_0	50	Ohm		FORCE_TR	1	logical	Floating Tap Control			
R_d	[50 50]	Ohm	[TX RX]	Include PCB	0	logical	N_bg	0	0 1 2 or 3 groups	
A_v	0.39	V	vp/vf=.694	TDR and ERL options			N_bf	0	taps per group	
A_fe	0.39	V	vp/vf=.694	TDR	1	logical	N_f	40	UI span for floating taps	
A_ne	0.578	V		ERL	1	logical	bmaxg	0.2	max DFE value for floating taps	
L	4			ERL_ONLY	0	logical				
M	32			TR_TDR	0.01	ns				
filter and Eq				N	3000					
f_r	0.75	*fb		beta_x	2.53E+09					
c(0)	0.54		min	rho_x	0.25					
c(-1)	[-0.26:0.02:0]		[min:step:max]	fixture delay time	0	s				
c(-2)	[0:0.02:0.10]		[min:step:max]	TDR_W_TXPKG	1		yellow indicates WIP			
c(-3)	[-0.04:0.02:0]		[min:step:max]	N_bx	24	UI				
c(1)	[-0.2:0.05:0]		[min:step:max]	Receiver testing						
N_b	4	UI		RX_CALIBRATION	0	logical				
b_max(1)	0.5			Sigma BBN step	5.00E-03	V				
b_max(2..N_b)	0.2			Noise, jitter						
g_DC	[-14:1:0]	dB	[min:step:max]	sigma_Rj	0.01	UI				
f_z	21.25	GHz		A_DD	0.02	UI				
f_p1	21.25	GHz		eta_0	8.20E-09	V^2/GHz				
f_p2	53.125	GHz		SNR_TX	33	dB				
g_DC_HP	[-3:1:0]		[min:step:max]	R_LM	0.95					
f_HP_PZ	0.6640625	GHz								

PS: Ran for test case 2 only

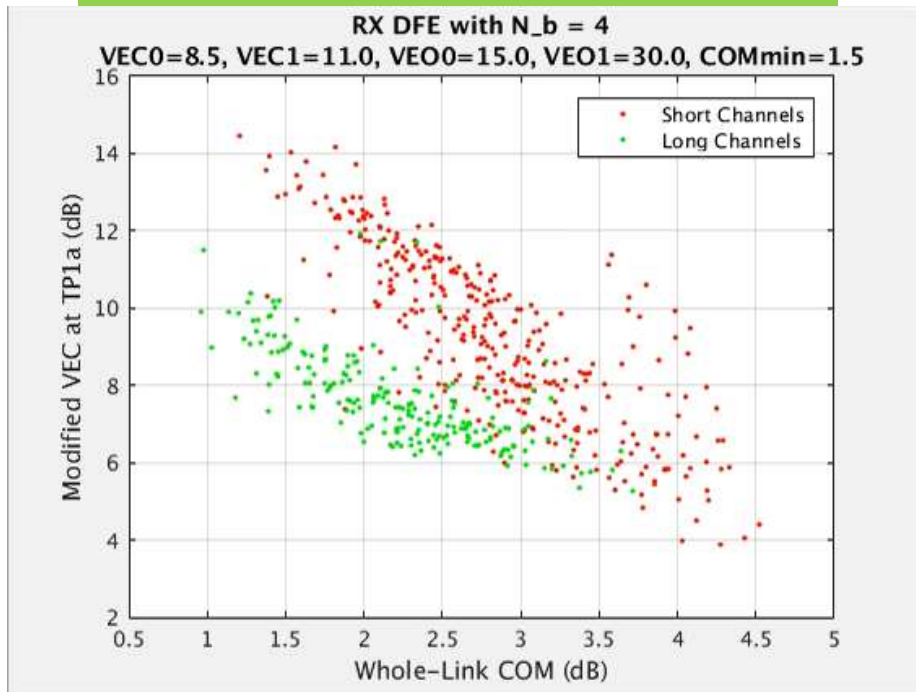
COM Settings – ERL Calculation

Table 93A-1 parameters				I/O control			Table 93A? parameters		
Parameter	Setting	Units	Information				Parameter	Setting	Units
f_b	53.125	GBd		DIAGNOSTICS	1	logical	package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
f_min	0.05	GHz		DISPLAY_WINDOW	0	logical	package_tl_tau	6.141E-03	ns/mm
Delta_f	0.01	GHz		CSV_REPORT	0	logical	package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
C_d	[1.2e-4 0]	nF	[TX RX]	RESULT_DIR	.\results\100GEL_KR_{date}\				
L_s	[0.12, 0]	nH	[TX RX]	SAVE_FIGURES	1	logical			
C_b	[0.3e-4 0]	nF	[TX RX]	Port Order	[2 1 4 3]		Table 92?2 parameters 5.2dB at 26.56GHz		
z_p select	[1 2]		[test cases to run]	RUNTAG	KR_eval_		Parameter	Setting	
z_p (TX)	[12 16; 1.8 1.8]	mm	[test cases]	COM_CONTRIBUTION	0	logical	board_tl_gamma0_a1_a2	[0 0.000599 0.0001022]	1.286 dB/in or 0.0506 dB/mm at 100 ohms
z_p (NEXT)	[0 0; 0 0]	mm	[test cases]	Operational			board_tl_tau	6.200E-03	ns/mm
z_p (FEXT)	[12 16; 1.8 1.8]	mm	[test cases]	COM Pass threshold	3	dB	board_Z_c	90	Ohm
z_p (RX)	[0 0; 0 0]	mm	[test cases]	ERL Pass threshold	10	dB	z_bp (TX)	102.7	mm
C_p	[0.87e-4 0]	nF	[TX RX]	DER_0	1.00E-04		z_bp (NEXT)	102.7	mm
R_0	50	Ohm		T_r	6.16E-03	ns	z_bp (FEXT)	102.7	mm
R_d	[50 50]	Ohm	[TX RX]	FORCE_TR	1	logical	z_bp (RX)	102.7	mm
A_v	0.39	V	vp/vf=.694	Include PCB	0	logical			
A_fe	0.39	V	vp/vf=.694	TDR and ERL options					
A_ne	0.578	V		TDR	1	logical			
L	4			ERL	1	logical	Floating Tap Control		
M	32			ERL_ONLY	1	logical	N_bg	0	0 1 2 or 3 groups
filter and Eq				TR_TDR	0.01	ns	N_bf	0	taps per group
f_r	0.75	*fb		N	2000		N_f	40	UI span for floating taps
c(0)	0.54		min	beta_x	2.34E+09		bmaxg	0.2	max DFE value for floating taps
c(-1)	[-0.26:0.02:0]		[min:step:max]	rho_x	0.3				
c(-2)	[0:0.02:0.10]		[min:step:max]	fixture delay time	0	s			
c(-3)	[-0.04:0.02:0]		[min:step:max]	TDR_W_TXPKG	1				
c(1)	[-0.2:0.05:0]		[min:step:max]	N_bx	4	UI	yellow indicates WIP		
N_b	4	UI		Receiver testing					
b_max(1)	0.5			RX_CALIBRATION	0	logical			
b_max(2..N_b)	0.2			Sigma BBN step	5.00E-03	V			
g_DC	[-14:1:0]	dB	[min:step:max]	Noise, jitter					
f_z	21.25	GHz		sigma_RJ	0.01	UI			
f_p1	21.25	GHz		A_DD	0.02	UI			
f_p2	53.125	GHz		eta_0	8.20E-09	V^2/GHz			
g_DC_HP	[-3:1:0]		[min:step:max]	SNR_TX	33	dB			
f_HP_PZ	0.6640625	GHz		R_LM	0.95				

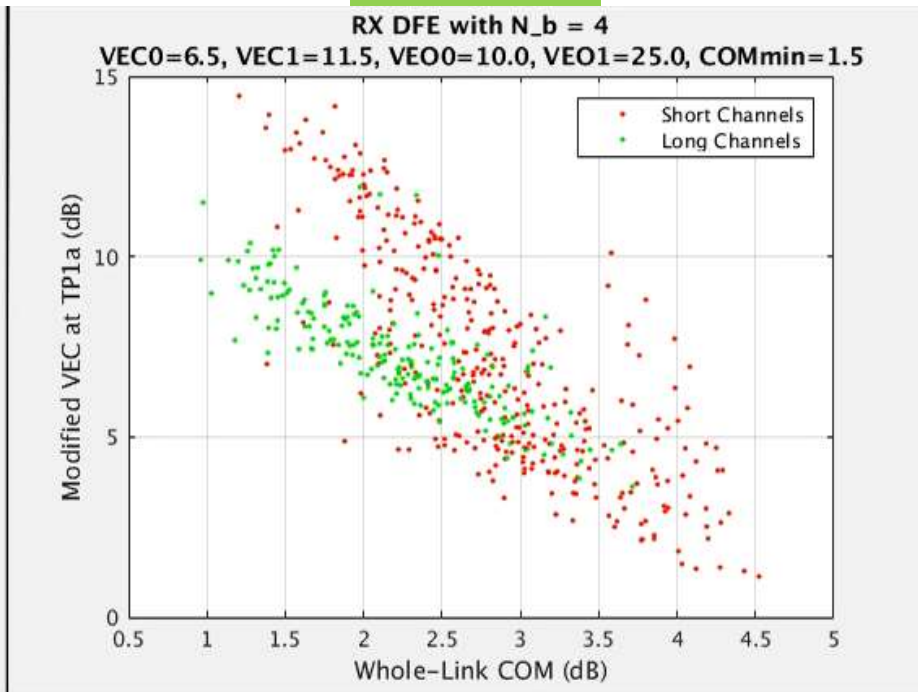
PS: Ran for test case 2 only

EVEC Parameters Comparison: Distribution

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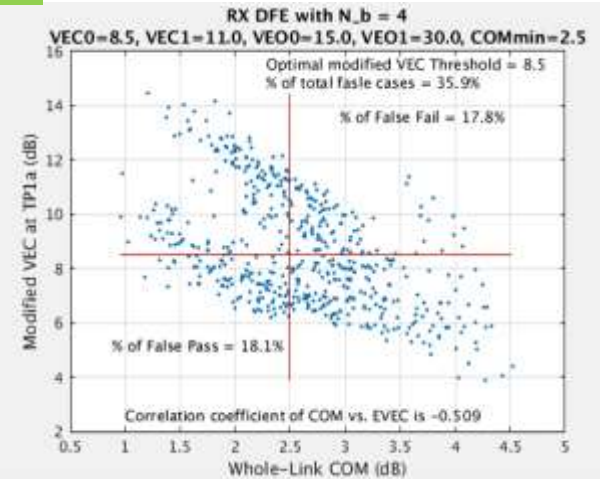
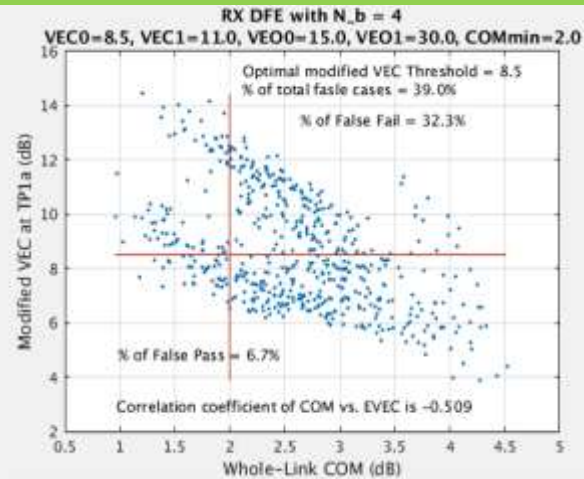
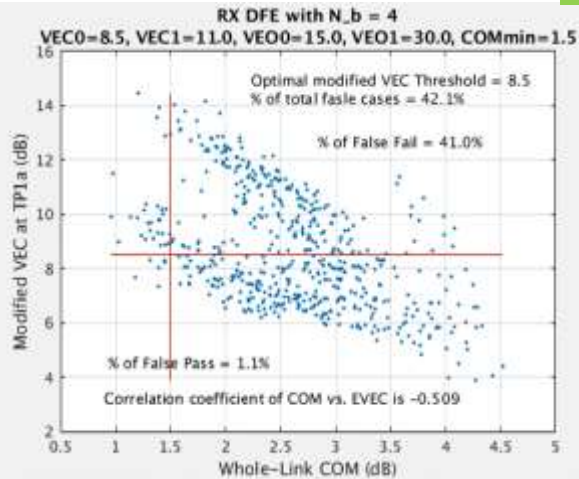


Proposal

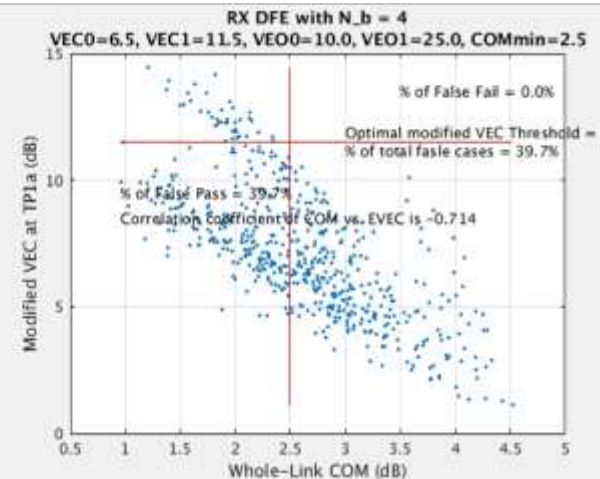
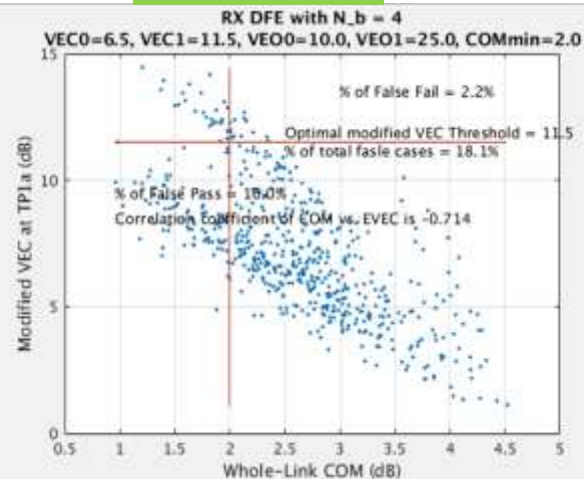
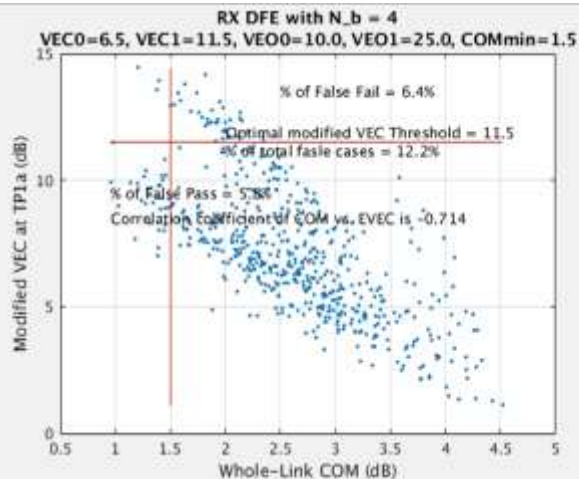


EVEC Parameters Comparison: False % & CC

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Proposal



ERL is NOT sensitive to Z_p1

